Analytical Chemistry in the System of Interrelationships among Disciplines Studied at Classical Universities

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Abstract—Interrelationships between a university course on analytical chemistry and other disciplines attended by students specializing in chemistry are discussed. The teaching of analytical chemistry at a level corresponding to the present state of the art requires optimizing the order of teaching of interdisciplinary courses and some changes in the curricula of these courses (especially, in physics). A consideration of interrelationships between disciplines also implies a modification of the course on analytical chemistry (to avoid doubling, etc.).

Curricula of analytical chemistry and other university disciplines are changeable and depend on many factors. One should take account of the current level of development of analytical chemistry as a science; general pedagogical principles; traditions of the higher education including national traditions; practical problems arising before young specialists (these problems are taken into account by the State Standards of the specialties); the time allotted for analytical chemistry; the background of students for further study; teachers’ skills in presenting certain material; the availability of textbooks; software; and equipment and their quality; etc. However, there is another factor. In defining the contents of the course on analytical chemistry, we should not forget that analytical chemistry is studied not independently but as a part of a unified system of disciplines at any institute of higher education. Unfortunately, this obvious statement is not adequately taken into account in practice. It is difficult to determine what material that is important for our course should be taught by interdisciplinary departments, on what actual knowledge of students the lecturers of analytical chemistry can rely, and what knowledge and skills in analysis will be required for further studies of other courses. In pedagogy, relevant problems are considered as a part of a global problem of interrelationships between disciplines.

In spite of the fact that interrelationships between disciplines are a basis for the strategic planning of the teaching process, chemistry teachers seldom think of relationships between chemistry and other disciplines. This is due to the comparative independence of university departments and lecturers, a teaching overload, and the weak interest of teachers in increasing a level of training as a whole but not in an individual discipline. The lack of training of many chemistry teachers in the methodology of higher professional education also complicates the situation. Note that interrelationships between disciplines in the higher education have a specific character [1]. The theory of interrelationships is developed very weakly as opposed to interrelationships of secondary-school subjects. Therefore, it seldom extends to practical recommendations.

The aim of this work is to examine interrelationships between analytical chemistry and other disciplines and propose recommendations concerned with the contents of interdisciplinary courses and order of studying these courses. I shall restrict myself by the frameworks of the specialty “011000: Chemistry,” that is, by the curriculum of universities with a single-level education system. This variant (with specialization) is a basic path for the professional training of analytical chemists in Russia.

This paper reflects the subjective opinion and experience of the author. Therefore, the considered problems are open for discussion. However, working on the paper, I impartially examined the curricula and typical and working schedules of various courses and textbooks. Questionnaire materials were used, including the opinions of heads of departments of analytical chemistry from various universities [2, 3].

Analytical chemistry in a curriculum. When should it be studied? In accordance with the State Standard of the specialty 011000, the course on analytical chemistry is an obligatory general discipline for all the students [4]. The matter of the course cannot depend on a future specialization of a student. It is determined by the university in accordance with the requirements of the State Standard and the detailed typical curriculum recommended by the Teaching and Methodological Association of Universities. The time allotted for this course cannot be less than 500 h spent by students for studies at home and the university, which corresponds to 250–300 h of studies at the university (300–400 h in most universities) [5]. In accordance with “The Standard Curriculum of the Spe-
cially 011000” [6] recommended by the Ministry of Education of the Russian Federation, students should attend the course on analytical chemistry in the second year (the third and forth terms) using the knowledge of inorganic chemistry and, partially, physics and mathematics, as well as secondary-school knowledge (Fig. 1). According to this curriculum, lecturers cannot use material of organic, colloid, quantum chemistry, or other courses studied at the third or fourth years. Even general regularities of chemical reactions cannot be used in teaching analytical chemistry because the curriculum implies studying physical chemistry in the forth year.

A university has the right to ignore the recommendations concerning the order of teaching of the courses. Therefore, actual curricula in many universities differ from the standard curriculum for training students in chemistry. Interrelationships between disciplines are largely taken into account. The curriculum accepted at Omsk State University serves as an example of such an approach (Fig. 2). Physical and analytical chemistry are studied simultaneously. The courses in mathematics and physics are studied during three terms instead of four terms (the total time allotted for this course remains the same). Therefore, in studying analytical chemistry, students can use the mathematical and physical tools more efficiently. Thus, analytical chemistry occupies a more favorable position from the viewpoint of interrelationships between the disciplines.

The problem of the interrelationship between analytical and organic chemistry is more difficult. In the standard and the majority of actual curricula, an extensive course on organic chemistry is studied after analytical chemistry, in the third year. However, the comparison of the standard curricula [7] shows that the interrelationships are directed mostly from organic to analytical chemistry, rather than the reverse. Therefore, the direction of interrelationships and the order of studying the disciplines are not in agreement. The present-day curriculum of analytical chemistry and the corresponding textbooks require of the student a certain knowledge of organic chemistry. A student should know molecular structures of organic reagents (for example, chelating agents and indicators); be able to predict reactivity, donor–acceptor properties, and acid–base characteristics of these molecules; know properties of various organic solvents (to select properly an extractant and titration medium); etc. Insertion of such a material in the course of analytical chemistry is quite reasonable. It is governed by the current level of analytical chemistry as a science. These sections cannot be excluded from the curriculum. Today, analysis of organic substances is no less, and even more, important than the analysis of inorganic substances. Organic solvents and reagents, themselves reactions of organic synthesis (like the Griess reaction) are very important for inorganic analysis as well. However, the relevant sections of analytical chemistry cannot be efficiently studied based on secondary-school organic chemistry. Especially if taking into account the fact that the secondary-school course has been gradually shortened in recent years.

On the other hand, the study of organic chemistry recommended by the Teaching and Methodological...